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NEW CHAPTERS IN

THE WARFARE OF SCIENCE

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BY

ANDREW DICKSON WHITE, LL. D., L. H. D.
EX-PRESIDENT OF CORNELL UNIVERSITY

XVII. GEOGRAPHY

REPRINTED FROM THE POPULAR SCIENCE MONTHLY
FOR AUGUST AND SEPTEMBER, 1892

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NEW CHAPTERS IN

THE WARFARE OF SCIENCE.

XVII.

GEOGRAPHY.

PART I.

1. THE FORM OF THE EARTH.—Among various rude tribes we find survivals of a primitive idea that the earth is a flat table or disk, ceiled, domed, or canopied by the sky, and that the sky rests upon the mountains as pillars. Such a belief is entirely natural; it conforms to the appearance of things, and hence has entered into various theologies.

In the early civilizations of Egypt and Chaldea it was very fully developed. The Egyptians considered the earth as a table, flat and oblong, the sky being its ceiling; a huge "firmament" of metal. At the four corners of the earth were the pillars supporting this firmament, and on this solid sky were the "waters above the heavens." They believed that, when chaos was taking form, one of the gods by main force raised the waters on high and spread them out over the firmament; that on the under side of this solid vault or ceiling or firmament the stars were suspended to light the earth, and that the rains were caused by the letting down of the waters through its windows. This idea and others connected with it seem to have taken strong hold of the Egyptian priestly caste, thus entering into their theology and sacred science: ceilings of great temples, with stars, constellations, planets, and signs of the zodiac figured upon them, remain to-day as striking evidences of this.

In India and Persia we have theories of geography based upon similar conceptions and embalmed in sacred texts. The Chaldeans also believed that a firmament was spread out over the earth, and that it supported the ocean of celestial waters, from which fell dew and rain.

From these sources came geographical legacies to the Hebrews:

various passages in their sacred books, many of them most noble in conception, and most beautiful in form, regarding the "firmament," the "corners of the earth," the "pillars of heaven," the "waters above the firmament," and the "windows of heaven," point us back to these ancient springs of thought.*

But as civilization was developed, there were evolved, especially among the Greeks, ideas of the earth's sphericity. The Pythagoreans, Plato, and Aristotle especially cherished them. These ideas were vague, they were mixed with absurdities, but they were germ ideas, and even amid the luxuriant growth of theology in the early Christian Church these germs began struggling into life in the minds of a few thinking men, and these men renewed the suggestion that the earth is a globe.†

A few of the larger-minded fathers of the Church, influenced possibly by Pythagorean traditions, but certainly by Aristotle and Plato, were willing to accept this view, but the majority of them took fright at once. To them it seemed fraught with dangers to Scripture, by which, of course, they meant *their inter-*

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* For survivals of the early idea, among the Eskimos, of the sky as supported by mountains, and, among sundry Pacific islanders, of the sky as a firmament or vault of stone, see Tylor, Early History of Mankind, second edition, London, 1870, chap. xi; Spencer, Sociology, vol. i, chap. viii; also Andrew Lang, La Mythologie, Paris, 1886, pp. 68–73. For the early view in India and Persia, see citations from the Vedas and the Zend-Avesta in Lethaby, Architecture, Mysticism, and Myth, chap. i. For the Egyptian view, see Champollion; also, Lenormant, Histoire Ancienne, Maspero, and others. As to the figures of the heavens upon the ceilings of Egyptian temples, see Maspero, Archéologie Egyptienne, Paris, 1890; and for engravings of them, see Lepsius, Denkmäler, vol. i, Bl. 41, and vol. ix, Abth. iv, Bl. 35; also the Déscription de l'Égypte published by order of Napoleon, tome ii, Pl. 14; also Prisse d'Avennes, Art Égyptien, Atlas, tome i, Pl. 35; and especially for a survival at the Temple of Denderah, see Denon, Voyage en Égypte, Planches 129, 130. For the Egyptian idea of "pillars of heaven," as alluded to on the stele of Victory of Thotmes III, in the Cairo Museum, see Ebers, Uarda, ii, 175, note, Leipsic, 1877. For a similar Babylonion belief, see Sayce's Herodotus, Appendix, 403. For the belief of Hebrew scriptural writers in a solid "firmament," see especially Job, xxxviii, 18; also Smith's Bible Dictionary.

† The agency of the Pythagoreans in first spreading the doctrine of the earth's sphericity is generally acknowledged, but the first clear and full utterance of it to the world was by Aristotle. Very fruitful, too, was the statement of the new theory given by Plato in the Timæus; see Jowett's translation, New York edition, 62, c. Also Phædo, pp. 449 *et seq.* See also Grote on Plato's doctrine of the sphericity of the earth; also Sir G. C. Lewis's Astronomy of the Ancients, London, 1862, chap. iii, section i, and note. Cicero's mention of the antipodes, and his reference to the passage in the Timæus are even more remarkable than the original, in that they much more clearly foreshadow the modern doctrine. See his Academic Questions, ii; also Tusc. Quest., i and v, 24. For a very full summary of the views of the ancients on the sphericity of the earth, see Kretchmer, Die physische Erdkunde im christlichen Mittelalter, Wien, 1889, pp. 35 *et seq.;* also, Eicken, Geschichte der mittelälterlichen Weltanschauung, Stuttgart, 1887, Dritter Theil, chap. vi. For citations and summaries, see Whewell, Hist. Induct. Sciences, vol. i, p. 189, and St. Martin, Hist. de la Géog., Paris, 1873, p. 96; also, Leopardi, Saggio sopra gli errori popolari degli antichi, Firenze, 1851, chapter xii, pp. 184 *et seq.*

pretation of Scripture. Among the first who took up arms against it was Eusebius. In view of the New Testament texts indicating the immediately approaching end of the world, he endeavored to turn off this idea by bringing scientific studies into contempt. Speaking of investigators, he said, "It is not through ignorance of the things admired by them, but through contempt of their useless labor, that we think little of these matters, turning our souls to better things." Basil of Cæsarea declared it "a matter of no interest to us whether the earth is a sphere or a cylinder or a disk, or concave in the middle like a fan." Lactantius referred to the ideas of those studying astronomy as "bad and senseless," and opposed the doctrine of the earth's sphericity both from Scripture and reason. St. John Chrysostom also exerted his influence against this scientific belief; and Ephrem Syrus, the greatest man of the old Syrian Church, widely known as the "lute of the Holy Ghost," opposed it no less earnestly.

But the strictly Biblical men of science, such eminent fathers and bishops as Theophilus of Antioch in the second century, Clement of Alexandria in the third, and others in centuries following, were not content with merely opposing what they stigmatized as an old heathen theory; they drew from their Bibles a new Christian theory, to which one church authority added one idea and another another, until it was fully developed. Taking the survival of various early traditions, given in the seventh verse of the first chapter of Genesis, they dwelt on the scriptural declaration that the earth was, at creation, arched over with a solid vault, "a firmament," and to this they added the passage from Isaiah in which it is declared that the heavens are stretched out "like a curtain," and again "like a tent to dwell in." The universe, then, is like a house: the earth is its ground floor, the firmament its ceiling, under which the Almighty hangs out the sun to rule the day, and the moon and stars to rule the night. This ceiling is also the floor of the apartment above, and in this is a cistern, shaped, as one of the authorities says, "like a bathing-tank," and containing "the waters which are above the firmament." These waters are let down upon the earth by the Almighty and his angels through the "windows of heaven." As to the movement of the sun, there was a citation of various passages in Genesis, mixed with metaphysics in various proportions, and this was thought to give ample proofs from the Bible that the earth could not be a sphere.*

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* For Eusebius, see the Prep. Ev., xv, 61. For Basil, see the Hexameron, Hom. ix, cited in Peschel, Erdkunde, p. 96, note. For Lactantius, see his Inst. Div., lib. iii, cap. 3; also, citations in Whewell, Hist. Induct. Sciences, London, 1857, vol. i, p. 194, and in St. Martin, Histoire de la Géographie, pp. 216, 217. For the views of St. John Chrysostom, Eph. Syrus, and other great churchmen, see Kretschmer as above, chap. i.

In the sixth century this development of theory culminated in what was nothing less than a complete and detailed system of the universe, claiming to be based upon Scripture, its author being the Egyptian monk Cosmas Indicopleustes. Egypt was a great treasure-house of theologic thought to various religions of antiquity, and Cosmas appears to have urged upon the early Church this Egyptian idea of the construction of the world, just as another Egyptian ecclesiastic, Athanasius, urged upon the Church the Egyptian triune idea of the gods ruling the world. According to Cosmas, the earth is a parallelogram, flat, and surrounded by four seas. It is four hundred days' journey long and two hundred broad. At the outer edges of these four seas arise massive walls closing in the whole structure and supporting the firmament or vault of the heavens, whose edges are cemented to the walls. These walls inclose the earth and all the heavenly bodies.

The whole of this theologic-scientific structure was built most carefully and, as was then thought, most scripturally. Starting with the expression applied in the ninth chapter of Hebrews to the tabernacle in the desert, Cosmas insists, with other interpreters of his time, that it gives the key to the whole construction of the world. The universe is, therefore, made on the plan of the Jewish tabernacle—box-like and oblong. Going into details, he quotes the sublime words of Isaiah: "It is He that sitteth upon the circle of the earth; . . . that stretcheth out the heavens like a curtain, and spreadeth them out like a tent to dwell in"; and the passage in Job, which speaks of the "pillars of heaven." He works all this into his system, and reveals, as he thinks, treasures of science.

This vast box is divided into two compartments, one above the other. In the first of these, men live and stars move; and it extends up to the first solid vault, or firmament, above which live the angels, a main part of whose business it is to push and pull the sun and planets to and fro. Next, he takes the text, "Let there be a firmament in the midst of the waters, and let it divide the waters from the waters," and other texts from Genesis; to these he adds the text from the Psalms, "Praise him, ye heaven of heavens, and ye waters that be above the heavens"; then casts all these growths of thought into his crucible together, and finally brings out the theory that over this first vault is a vast cistern containing "the waters." He then takes the expression in Genesis regarding the "windows of heaven" and establishes a doctrine regarding the regulation of the rain, to the effect that the angels not only push and pull the heavenly bodies to light the earth, but also open and close the heavenly windows to water it.

To understand the surface of the earth, Cosmas studies the table of show-bread in the Jewish tabernacle. The surface of this table proves to him that the earth is flat, and its dimensions prove that the earth is twice as long as broad; its four corners symbolize the four seasons; the twelve loaves of bread, the twelve months; the hollow about the table proves that the ocean surrounds the earth. To account for the movement of the sun, Cosmas suggests that at the north of the earth is a great mountain, and that at night the sun is carried behind this; but some of the commentators ventured to express a doubt here; they thought that the sun was pushed into a great pit at night and pulled out in the morning.

Nothing can be more touching in its simplicity than Cosmas's summing up of his great argument. He declares, "We say therefore with Isaiah that the form of the heaven that embraces the universe is that of a vault, with Job that it is joined to the earth, and with Moses that the length of the earth is greater than its breadth." The treatise closes with rapturous assertions that not only Moses and the prophets, but also angels and apostles, agree to the truth of his doctrine, and that at the last day God will condemn all who do not accept it.

Although this theory was universally considered as drawn from Scripture, it was really, as we have seen, the result of an evolution of theological thought begun long before the texts on which it nominally rested were written. It was not at all strange that Cosmas, Egyptian as he was, should have received this old Nile-born doctrine, as we see it indicated to-day in the structure of Egyptian temples, and that he should have developed it by the aid of the Jewish Scriptures. But the theological world knew nothing of its more remote pagan evolution; it was received as virtually inspired, and was soon regarded as a fortress of scriptural truth. Some of the foremost men in the Church devoted themselves to buttressing it with new texts and throwing about it new outworks of theological reasoning; the great body of the faithful considered it a direct gift from the Almighty.*

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* For a notice of the views of Cosmas in connection with those of Lactantius, Augustine, St. John Chrysostom, and others, see Schoell, Histoire de la Littérature Grecque, vol. vii, p. 37. The main scriptural passages referred to are as follows: (1) Isaiah xl, 22; (2) Genesis i, 6; (3) Genesis vii, 11; (4) Exodus xxiv, 10; (5) Job xxvi, 11, and xxxvii, 18; (6) Psalm cxlviii, 4, and civ, 9; (7) Ezekiel i, 22–26. For Cosmas's theory see Montfaucon, Collectio Nova Patrum, Paris, 1706, vol. ii, p. 188; also pp. 298, 299. The text is illustrated with engravings showing walls and solid vault (firmament), with the whole apparatus of "fountains of the great deep," "windows of heaven," angels, and the mountain behind which the sun is drawn. For reduction of one of them see Peschel, Geschichte der Erdkunde, p. 98; also article "Maps," in Knight's Dictionary of Mechanics, New York, 1875. For a good discussion of Cosmas's ideas, see Santarem, Hist. de la Cosmographie, vol. ii, pp. 8 *et seq.*, and for a very thorough discussion of its details, Kretschmer, as above. For still another theory, very droll, and thought out on similar principles, see Mungo Park, cited in De Morgan, Paradoxes, 309. For Cosmas's joyful summing up, see Montfaucon,

From this old conception of the universe as a sort of house, with heaven as its upper story and the earth as its ground floor, flowed important theological ideas into heathen, Jewish, and Christian mythologies. Common to them all are legends regarding attempts of mortals to invade the upper apartment from the lower. Of such are the Greek legends of the Aloidae who sought to reach heaven by piling up mountains, and were cast down; the Chaldean and Hebrew legends of the wicked who at Babylon sought to build "a tower whose top may reach heaven," which Jehovah went down from heaven to see, and which he brought to naught by the "confusion of tongues"; the Hindoo legend of the tree which sought to grow into heaven and which Brahma blasted; and the Mexican legend of the giants who sought to reach heaven by building the Pyramid of Cholula, and who were overthrown by fire from above.

Myths having this geographical idea as their germ developed in luxuriance through thousands of years. Ascensions to heaven and descents from it, "translations," "assumptions," "annunciations," mortals "caught up" into it and returning, angels flying between it and the earth, thunderbolts hurled down from it, mighty winds issuing from its corners, voices speaking from the upper floor to men on the lower, temporary openings of the floor of heaven to reveal the blessedness of the good, "signs and wonders" hung out from it to warn the wicked, interventions of every kind, from the heathen gods coming down on every sort of errand, and Jehovah coming down to walk in Eden in the cool of the day, to St. Mark swooping down into the market-place of Venice to break the shackles of a slave—all these are but features in a vast evolution of myths arising largely from this geographical germ.

Nor did this evolution end here. Naturally, in this view of things, if heaven was a loft, hell was a cellar; and if there were ascensions into one, there were descents into the other. Hell being so near, interferences by its occupants with the dwellers of the earth just above were constant and form a vast chapter in mediæval literature. Dante made this conception of the location of hell still more vivid, and we find some forms of it serious barriers to geographical investigation. Many a bold navigator, who was quite ready to brave pirates and tempests, trembled at the thought of tumbling with his ship into one of the openings into hell which a wide-spread belief placed in the Atlantic at some unknown distance from Europe. This terror of the sailors was one of the main obstacles in the great voyage of Columbus. In an

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Collectio Nova Patrum, vol. ii, p. 255. For the Egyptian Trinitarian views, see Sharpe, History of Egypt, vol. i, pp. 94, 102.

Anglo-Saxon tract, giving science the form of a dialogue, occur the following question and answer: "Why is the sun so red in the evening?" "Because he looketh down upon hell."

But the ancient germ of scientific truth in geography still lived, and a hundred years after Cosmas it gets new life from a great churchman of southern Europe, Isidore of Seville, who, however fettered by the dominant theology in many other things, braved it in this. In the eighth century a similar declaration is made in the north of Europe by another great church authority, Bede. Against the new life thus given to the old truth, the sacred theory struggled long and vigorously but in vain. Eminent authorities in later ages, like Albert the Great, St. Thomas Aquinas, Dante, and Vincent of Beauvais, felt obliged to accept the doctrine of the earth's sphericity, and as we approach the modern period we find its truth acknowledged by the vast majority of thinking men.*

2. THE DELINEATION OF THE EARTH.—Every great people of antiquity, as a rule, regarded its own central city or most holy place as necessarily the center of the earth.

The Chaldeans held that their "holy house of the gods" was the center. The Egyptians sketched the world under the form of a human figure, in which Egypt was the heart, and the center of it, Thebes. For the Assyrians, it was Babylon; for the Hindoos, it was Mount Meru; for the Greeks, so far as the civilized world was concerned, Olympus or the temple at Delphi; for the modern Mohammedans, it is Mecca and its sacred stone; the Chinese, to this day, speak of their empire as the "middle kingdom." It was in accordance, then, with a simple tendency of human thought that the Jews believed the center of the world to be Jerusalem.

The book of Ezekiel speaks of Jerusalem as in the middle of the earth, and all other parts of the world as set around the holy city. Throughout the "ages of faith" this was very generally accepted as a direct revelation from the Almighty regarding the earth's form. St. Jerome, the greatest authority of the early Church upon the Bible, declared, on the strength of this utterance of the prophet, that Jerusalem must stand at the earth's center; in the ninth century Archbishop Rabanus Maurus reiterated the same argument; in the eleventh century, Hugh of St. Victor gave to the doctrine another scriptural demonstration; and Pope Urban, in his great sermon at Clermont urging the Franks to the crusade, declared, "Jerusalem is the middle point of the earth";

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* For a discussion of the geographical views of Isidore and Bede, see Santarem, Cosmographie, vol. i, pp. 22–24. For the gradual acceptance of the idea of the earth's sphericity after the eighth century, see Kretschmer, pp. 51 *et seq.*, where citations from a multitude of authors are given.

in the thirteenth century, another of the mediæval Church authorities, Cæsar of Heisterbach, declared, "As the heart in the midst of the body, so is Jerusalem situated in the midst of our inhabited earth"; "so it was that Christ was crucified at the center of the earth." Dante accepted this view of Jerusalem as a certainty and wedded it to immortal verse.

Ezekiel's statement thus became the standard of orthodoxy to early map-makers. The map of the world at Hereford Cathedral, the maps of Andrea Bianco, Marino Sanuto, and a multitude of others fixed this view in men's minds, and doubtless helped during many generations to discourage any scientific statements tending to unbalance this geographical center supposed to be revealed in Scripture.*

Nor did mediæval thinkers rest with this conception. In accordance with the dominant view that physical truth must be sought by theological reasoning, the idea was evolved that not only the site of the cross on Calvary marked the geographical center of the world, but that on this very spot had stood the tree which bore the forbidden fruit in Eden. Thus was geography made to reconcile all parts of the great theologic plan. This doctrine was hailed with joy by multitudes; and we find in the works of mediæval pilgrims to Palestine, again and again, evidence that this had become precious truth to them, both in theology and geography.*

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* For the beliefs of various nations of antiquity that the earth's center was in their most sacred place, see citations from Maspero, Charton, Sayce, and others in Lethaby, Architecture, Mysticism, and Myth, chap. iv. As to the Greeks, we have typical statements in the Eumenides of Æschylus, where the stone on the altar at Delphi is repeatedly called "the earth's navel"—which is precisely the expression used regarding Jerusalem in the Septuagint translation of Ezekiel (see note below). The proof texts on which the mediæval geographers mainly relied as to the form of the earth were Ezekiel, v, 5, and xxxviii, 12. The progress of geographical knowledge evidently caused them to be softened down somewhat in our King James's version; but the first of them reads, in the Vulgate, "*Ista est Hierusalem, in medio gentium posui eam et in circuitu ejus terræ*"; and the second reads, in the Vulgate, "*in medio terræ,*" and in the Septuagint, ἐπὶ τὸν ὀμφαλὸν τῆς γῆς. That the literal center of the earth was understood, see proof in St. Jerome, Commentar. in Ezekiel, lib. ii; and for general proof, see Leopardi, Saggio sopra gli errori popolari degli antichi, pp. 207, 208. For Rabanus Maurus, see his De Universo, lib. xii, cap. 4, in Migne, tome cxi, p. 339. For Hugh of St. Victor, see his De Situ Terrarum, cap. ii. For Dante's belief, see Inferno, canto xxxiv, 112–115:

"E se' or sotto l'emisperio giunto,
Ch' è opposito a quel che la gran secca
Coverchia, e sotto il cui colmo consunto
Fu l'uom che nacque e visse senza pecca."

For orthodox geography in the middle ages, see Wright's Essays on Archæology, vol. ii, chapter on the map of the world in Hereford Cathedral; also the rude maps in Cardinal d'Ailly's Ymago Mundi; also copy of maps of Marino Sanuto and others in Peschel, Erdkunde, p. 210; also Münster, Fac Simile dell' Atlante de Andrea Bianco, Venezia, 1869. And for discussions of the whole subject, see Santarem, vol. ii, p. 295, vol. iii, pp. 71, 183, 184, and elsewhere. For a brief summary with citations, see Eicken, Geschichte, etc., pp. 622, 623.

Nor was this the only misconception which forced its way from our sacred writings into mediæval map-making; two others were almost as marked.

First of these was the vague terror inspired by Gog and Magog. Few passages in the Old Testament are more sublime than the denunciation of these great enemies by Ezekiel; and the well-known statement in the Apocalypse fastened the Hebrew feeling regarding them with a new meaning into the mind of the early Church: hence it was that the mediæval map-makers took great pains to delineate these monsters and their habitations on the maps. For centuries no map was considered orthodox which did not show them.

The second conception was derived from the frequent mention in our sacred books of the "four winds." Hence came a vivid belief in their real existence and their delineation on the maps, generally as colossal heads with distended cheeks, blowing vigorously toward Jerusalem.

Even at a period after these conceptions had mainly disappeared we find here and there evidences of the difficulty men found in giving up the scriptural idea of direct personal interference by agents of Heaven in the ordinary phenomena of Nature: thus in a noted map of the sixteenth century representing the earth as a sphere, there is at each pole a crank, with an angel laboriously turning the earth by means of it.†

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* For the site of the cross on Calvary, as the point where stood "the tree of the knowledge of good and evil" in Eden, at the center of the earth, see various Eastern travelers cited in Tobler; but especially the travels of Bishop Arculf in the Holy Land in Wright's Early Travels in Palestine, p. 8; also, Travels of Saewulf, ibid., p. 38; also, Sir John Maundeville, ibid., pp. 166, 167; and for one narrative in which the idea was developed into an amazing mass of pious myths, see Pilgrimage of the Russian Abbot Daniel, edited by Sir C. W. Wilson, London, 1885, p. 14. (The passage deserves to be quoted as an example of myth-making; it is as follows: "At the time of our Lord's crucifixion, when he gave up the ghost on the cross, the veil of the temple was rent, and the rock above Adam's skull opened, and the blood and water which flowed from Christ's side ran down through the fissure upon the skull, thus washing away the sins of men.")

† For Gog and Magog, see Ezekiel, chaps. xxxviii and xxxix, and Rev. xx, 8; and for the general subject, Toy, Judaism and Christianity, Boston, 1891, pp. 373, 374. For maps showing these two great terrors, and for geographical discussion regarding them, see Lelewel, Géog. du Moyen Age, Bruxelles, 1850, Atlas; also Ruge, Gesch. des Zeitalters der Entdeckungen, Berlin, 1881, pp. 78, 79; also Peschel's Abhandlungen, pp. 28–35, and Gesch. der Erdkunde, p. 210. For representations on maps of the "Four Winds," see Charton, Voyageurs, tome ii, p. 11; also Ruge as above, pp. 324, 325; also, for a curious mixture of the scriptural four winds with the classical winds issuing from the bags of Æolus, see a map of the twelfth century in Léon Gautier, La Chevalerie, p. 153; and for maps showing additional winds, see various editions of Ptolemy. For a map with angels turning the earth by means of cranks at the poles, see Grynæus, Novus Orbis, Basileæ, 1537.

PART II.

3. THE INHABITANTS OF THE EARTH.—Even while the question of the sphericity of the earth was undecided, another question had been suggested which the Church held to be of far greater importance. The doctrine of the earth's sphericity naturally led to thought upon the tenants of the earth's surface, and another ancient germ idea was warmed into life—the idea of the antipodes—of human beings on the earth's opposite sides.

At this the theological warriors of the Church waxed valiant. Those great and good churchmen determined to fight. To all of them this idea seemed dangerous, to most of them it seemed damnable. St. Basil and St. Ambrose were tolerant enough to allow that a man might be saved who thought the earth inhabited on its opposite sides, but the great majority of the fathers of the Church doubted the possibility of salvation to such misbelievers.

Lactantius asks: "Is there any one so senseless as to believe that there are men whose footsteps are higher than their heads? . . . that the crops and trees grow downward? . . . that the rains and snow and hail fall upward toward the earth? . . . I am at a loss what to say of those who, when they have once erred, steadily persevere in their folly, and defend one vain thing by another."

But a still greater man followed on the same side. St. Augustine seemed inclined to yield a little in regard to the sphericity of the earth, but he fought the idea that men exist on the other side of it, saying that "Scripture speaks of no such descendants of Adam." He insists that men could not be allowed by the Almighty to live there, since if they did they could not see Christ at his second coming descending through the air. But his most cogent appeal, one which we find echoed from theologian to theologian during a thousand years afterward, is to the nineteenth Psalm, and to its confirmation in the Epistle to the Romans; to the words, "Their line is gone out through all the earth, and their words to the end of the world." He dwells with great force on the fact that St. Paul based one of his most powerful arguments upon this declaration regarding the preachers of the gospel, declaring even more explicitly that "verily their sound went into all the earth, their words unto the ends of the world." Henceforth we find it constantly declared that, as those preachers did not go to the antipodes, no antipodes can exist; and therefore that the supporters of this geographical doctrine "give the lie direct to King David and to St. Paul, and therefore to the Holy Ghost." Augustine taught the whole world for over a thousand years that as there was no preaching of the gospel on the opposite side of the earth, there could be no human beings there.

The great authority of Augustine and the cogency of his scriptural argument held the Church, as a rule, firmly against the doctrine of the antipodes; yet that the doctrine continued to have life is shown by the fact that in the sixth century Procopius of Gaza attacks it with a tremendous argument. He declares that if there be men on the other side of the earth, Christ must have come to save them; and, therefore, that there must have been there, as necessary preliminaries to his coming, a duplicate Eden, Adam, Serpent, and Deluge.

Cosmas Indicopleustes also attacked the doctrine with especial bitterness, citing a passage from St. Luke to prove that antipodes are theologically impossible.

At the end of the sixth century comes a man from whom much might be expected—St. Isidore of Seville. He had pondered over ancient thought in science, and, as we have seen, had dared proclaim his belief in the sphericity of the earth; but with that he stopped. As to the antipodes, the authority of the Psalmist, St. Paul, and St. Augustine silences him; he shuns the whole question as unlawful, subjects reason to faith, and declares that men can not and ought not to exist on opposite sides of the earth.*

Under such pressure this scientific truth seems to have disappeared for nearly two hundred years, but by the eighth century the sphericity of the earth had come to be generally accepted among the leaders of thought, and now the doctrine of the antipodes was again asserted by a bishop, Virgil of Salzburg.

There then stood in Germany, in those first years of the eighth century, one of the greatest and noblest of men—St. Boniface. His learning was of the best then known. In labors he was a worthy successor of the apostles; his genius for Christian work made him unwillingly primate of Germany; his devotion to duty led him willingly to martyrdom. There sat too, at that time, on the papal throne a great Christian statesman — Pope Zachary. Boniface immediately declared against the revival of such a heresy as the doctrine of the antipodes; he stigmatized it as an assertion that there are men beyond the reach of the appointed means of salvation; he attacked Virgil, and called on Pope Zachary for aid.

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* For the opinions of Basil, Ambrose, and others, see Lecky, History of Rationalism in Europe, New York, 1872, vol. i, p. 279, note. Also Letronne, in Revue des Deux Mondes, March, 1834. For Lactantius, see citations already given. For St. Augustine's opinion, see the Civ. Dei, xvi, 9, where this great father of the Church shows that the existence of the antipodes "nulla ratione credendum est." Also citations in Buckle's Posthumous Works, vol. ii, p. 645. For Procopius of Gaza see Kretschmer, p. 55. See also, on the general subject, Peschel, Geschichte der Erdkunde, pp. 96, 97. For Isidore, see citations already given. To understand the embarrassment caused by these utterances of the fathers to scientific men of a later period, see Letter of Agricola to Joachimus Vadianus in 1514. Agricola asks Vadianus to give his views regarding the antipodes, saying that he himself does not know what to do, between the fathers on the one side and the learned men of modern times on the other. On the other hand, for the embarrassment caused to the Church by this mistaken zeal of the fathers, see Kepler's references and Fromund's replies; also De Morgan, Paradoxes, p. 58. Kepler appears to have taken great delight in throwing the views of Lactantius into the teeth of his adversaries.

The Pope, as the infallible teacher of Christendom, makes a strong response. He cites passages from the book of Job and the Wisdom of Solomon against the doctrine of the antipodes; he declares it "perverse, iniquitous, and against Virgil's own soul," and indicates a purpose of driving him from his bishopric. Whether this purpose was carried out or not, the old theological view, by virtue of the Pope's divinely ordered and protected "inerrancy," was re-established, and the doctrine that the earth has inhabitants on but one of its sides became more than ever orthodox, and, in the mind of the Church, necessary to salvation.*

This decision seems to have been regarded as final, and two centuries later the great encyclopedist of the middle ages, Vincent de Beauvais, though he accepts the sphericity of the earth, treats the doctrine of the antipodes as utterly disproved. Yet the doctrine still lived. Just as it had been previously revived by William of Conches and then laid to rest, so now it is somewhat timidly brought out in the thirteenth century by no less a personage than Albert the Great, the most noted man of science in that time. But his utterances are perhaps purposely obscure. Again it disappears beneath the theological wave, and a hundred years later Nicolas d'Oresme, Geographer of the King of France, a light of science, is forced to yield to the clear teaching of the Scripture as cited by St. Augustine.

Nor was this the worst. In Italy, at the beginning of the fourteenth century, the Church thought it necessary to deal with questions of this sort by rack and fagot. In 1316 Peter of Abano, famous as a physician, having promulgated this with other obnoxious doctrines in science, only escaped the Inquisition by death; and in 1327 Cecco d'Ascoli, noted as an astronomer, was for this and similar crimes driven from his professorship at Bologna and burned alive at Florence. Nor was this all his punishment: that great painter, Orcagna, whose terrible works still exist on the walls of the Campo Santo at Pisa, immortalized Cecco by representing him in the flames of hell.*

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* For Virgil of Salzburg, see Neander's History of the Christian Church, Torrey's translation, vol. iii, p. 63. Also Herzog, Real. Encyclopaedie, etc., recent edition by Prof. Hauck, *in verb. Virgilius.* Also Kretschmer. See Whewell, i, p. 197; but for best choice of authorities and for most careful winnowing out of conclusions, see De Morgan, pp. 24–26. For very full notes as to pagan and Christian advocates of the doctrine of the sphericity of the earth and of the antipodes, and for extract from Zachary's letter, see Migne, Patrologia, vol. vi, p. 426, and vol. xli, p. 487. For St. Boniface's part, see Bonifacii Epistolæ, ed. Giles, i, 173.

Years rolled on, and there comes in the fifteenth century one from whom the world had a right to expect much. Pierre d'Ailly, by force of thought and study had risen to be Provost of the College of St. Dié in Lorraine; his ability had made that little country village a center of scientific thought for all Europe, and finally made him Archbishop of Cambray and a cardinal. In 1483 was printed what Cardinal d'Ailly had written long before as a summing up of his best thought and research—the collection of essays known as the Ymago Mundi. It gives us one of the most striking examples in history of a great man in theological fetters. As he approaches this question he states it with such clearness that we expect to hear him assert the truth; but there stands the argument of St. Augustine; there, too, stands the biblical texts on which it is founded; the text from the Psalms and the explicit declaration of St. Paul to the Romans, "Their sound went into all the earth, and their words unto the ends of the world." D'Ailly attempts to reason, but he is overawed, and gives to the world virtually nothing.

Still, the doctrine of the antipodes lived and moved: so much so, that the eminent Spanish theologian Tostatus, even as late as the age of Columbus, feels called upon to protest against it as "unsafe." He has shaped the old missile of St. Augustine into the following syllogism: "The apostles were commanded to go into all the world and to preach the gospel to every creature; they did not go to any such part of the world as the antipodes; they did not preach to any creatures there; *ergo*, no antipodes exist."

The warfare of Columbus the world knows well—how the Bishop of Ceuta worsted him in Portugal; how sundry wise men of Spain confronted him with the usual quotations from the Psalms, from St. Paul, and from St. Augustine; how, even after he was triumphant, and after his voyage had greatly strengthened the theory of the earth's sphericity, with which the theory of antipodes was so closely connected, the Church by its highest authority solemnly stumbled and persisted in going astray. In 1493 Pope Alexander VI, having been appealed to as an umpire between the claims of Spain and Portugal to the newly discovered parts of the earth, issued a bull laying down upon the earth's surface a line of demarkation between the two powers. This line was drawn from north to south a hundred leagues west of the Azores; and the Pope in the plenitude of his knowledge declared that all lands discovered east of this line should belong to the Portuguese and all west of it should belong to the Spaniards. This was hailed as an exercise of divinely illuminated power by the Church; but difficulties arose, and in 1506 another attempt was made by Pope Julius II to draw the line three hundred and seventy leagues west of the Cape Verd Islands. This, again, was supposed to bring divine wisdom to settle the question, but shortly overwhelming difficulties arose; for the Portuguese claimed Brazil, and, of course, had no difficulty in showing that they could reach it by sailing to the east of the line, provided they sailed long enough. The lines laid down by Popes Alexander and Julius may still be found upon the maps of the period, but their bulls have quietly passed into the catalogue of ludicrous errors.

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* For Vincent de Beauvais and the antipodes, see his Speculum Naturales, Book VII, with citations from St. Augustine, De Civitate Dei, cap. xvi. For Albert the Great's doctrine regarding the antipodes, compare Kretschmer as above with Eicken, Geschichte, etc., p. 621. Kretschmer finds that Albert supports the doctrine, and Eicken finds that he denies it—a fair proof that Albert was not inclined to state his views with dangerous clearness. For D'Oresme, see Santarem, Histoire de la Cosmographie, vol. i, p. 142. For Peter of Abano, or Apono, as he is often called, see Tiraboschi; also Ginguené, vol. ii, p. 293; also Naudé, Histoire des Grands Hommes de Magie. For Cecco d'Ascoli, see Montucla, Histoire des Mathematiques, i, 528; also Daunou, Études Historiques, vol. vi, p. 320; also Kretschmer, p. 59. Concerning Orcagna's representation of Cecco in flames of hell, see Renan, Averroes et l'Averroisme, Paris, 1867, p. 328.

Yet the theological barriers to this geographical truth yielded but slowly. Plain as it had become to scholars, they hesitated to declare it to the world at large. Eleven hundred years had passed since St. Augustine had proved its antagonism to Scripture, when Gregory Reysch gave forth his famous encyclopædia, the Margarita Philosophica. Edition after edition was issued, and everywhere appeared in it the orthodox statements; but they were evidently strained to the breaking point; for, while in treating of the antipodes Reysch refers respectfully to St. Augustine as objecting to the scientific doctrine, he is careful not to cite Scripture against it, and is not less careful to cite geographical reasoning in favor of it.

But in 1519 science gains a crushing victory. Magellan makes his famous voyage. He proves the earth to be round, for his expedition circumnavigates it; he proves the doctrine of the antipodes, for he sees the peoples of the antipodes. Yet even this does not end the war. Many conscientious men oppose the doctrine for two hundred years longer. Then the French astronomers make their measurements of degrees in equatorial and polar regions, and add to their proofs that of the lengthened pendulum. When this was done, when the deductions of science were seen to be established by the simple test of measurement, beautifully and perfectly, and when a long line of trustworthy explorers had sent home accounts of the antipodes, then, and then only, this war of twelve centuries ended.

Such was the main result of this long war; but there were other results not so fortunate. The efforts of Eusebius, Basil, and Lactantius to deaden scientific thought; the efforts of Augustine to combat it; the efforts of Cosmas to crush it by dogmatism; the efforts of Boniface and Zachary to crush it by force, conscientious as they all were, had resulted simply in impressing upon many noble minds the conviction that science and religion are enemies.

On the other hand, what was gained by the warriors of science for religion? Certainly a far more worthy conception of the world and a far more ennobling conception of that Power which pervades and directs it. Which is more consistent with a great religion, the cosmography of Cosmas or that of Isaac Newton? Which presents a nobler field for religious thought, the diatribes of Lactantius or the calm statements of Humboldt? *

4. THE SIZE OF THE EARTH.—But at an early period another subject in geography had stirred the minds of thinking men—the earth's size. Various ancient investigators had by different methods reached measurements more or less near the truth; these methods were continued into the middle ages, supplemented by new thought, and among the more striking results were those obtained by Roger Bacon and Gerbert, afterward Pope Sylvester II. They handed down to after-time the torch of knowledge, but, as their reward among their contemporaries, they fell under the charge of sorcery.

Far more consonant with the theological spirit of the middle ages was a solution of the problem from Scripture, and this

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* For D'Ailly's acceptance of St. Augustine's argument, see the Ymago Mundi, Paris, 1490, cap. vii. For Tostatus, see Zöckler, vol. i, pp. 467, 468. He based his opposition on Romans, x. 18. For Columbus, see Winsor, Fiske, and Adams; also Humboldt, Histoire de la Géographie du Nouveau Continent. For the bull of Alexander VI, see Daunou, Ètudes Historiques, vol. ii, p. 417; also Peschel, Zeitalter der Entdeckungen, Book II, chap. iv. The text of the bull is given with the English translation in Arber's reprint of The First Three English Books on America, etc., etc., Birmingham, 1885, pp. 201–204; also especially Peschel, Die Theilung der Erde unter Papst Alexander VI. und Julius II., Leipsic, 1871, pp. 14 *et seq.* For remarks on the power under which the line was drawn by Alexander VI, see Mamiani, Del Papato ne'i Tre Ultimi Secoli, p. 170. For maps showing lines of division, see Kohl, Die beiden altesten General-Karten von Amerika, Weimar, 1860, where maps of 1527 and 1529 are reproduced; also Mercator, Atlas, tenth edition, Amsterdam, 1628, pp. 70, 71. For latest discussion on The Demarkation Line of Alexander VI, see E. G. Bourne in Yale Review, May, 1892. For the Margarita Philosophica, see the editions of 1503, 1509, 1517, lib. vii, cap. 48. For the effect of Magellan's voyages, and the reluctance to yield to proof, see Henri Martin, Histoire de France, vol. xiv, p. 395; St. Martin's Histoire de la Géographie, p. 369; Peschel, Geschichte des Zeitalters der Entdeckungen, concluding chapters; and for an admirable summary, Draper, Hist. Int. Devel. of Europe, pp. 451–453; also an interesting passage in Sir Thomas Browne's Vulgar and Common Errors, Book I, chap. vi. For general statement as to supplementary proof by measurement of degrees and by pendulum, see Somerville, Phys. Geog., chap. i, par. 6, note; also Humboldt, Cosmos, vol. ii, p. 736, and v, pp. 16, 32; also Montucla, iv, 138.

solution deserves to be given as an example of a very curious theological error, chancing to result in great good. The second book of Esdras, which among Protestants is placed in the Apocrypha, was held by many of the foremost men of the ancient Church as fully inspired: though Jerome looked with suspicion on this book, it was regarded as prophetic by Clement of Alexandria, Tertullian, and Ambrose, and the Church acquiesced in that view. In the Eastern Church it held an especially high place, and in the Western Church, before the Reformation, was generally considered by the most eminent authorities to be part of the sacred canon. In the sixth chapter of this book there is a summary of the works of creation, and in this occur the following verses:

"Upon the third day thou didst command that the waters should be gathered in the seventh part of the earth: six parts hast thou dried up and kept them to the intent that of these some, being planted of God and tilled, might serve thee."

"Upon the fifth day thou saidst unto the seventh part where the waters were gathered, that it should bring forth living creatures, fowls and fishes, and so it came to pass."

These statements were reiterated in other verses, and were naturally considered as of controlling authority.

Among the scholars who pondered on this as on all other things likely to increase knowledge was Cardinal Pierre d'Ailly. As we have seen, this great man, while he denied the existence of the antipodes as St. Augustine had done, believed firmly in the sphericity of the earth, and, interpreting these statements of the book of Esdras in connection with this belief, he held that, as only one seventh of the earth's surface was covered by water, the ocean between the west coast of Europe and the east coast of Asia could not be very wide. Knowing, as he thought, the extent of the land upon the globe, he felt that in view of this divinely authorized statement the globe must be much smaller, and the land of "Zipango," reached by Marco Polo, on the extreme east coast of Asia, much nearer than had been generally believed.

On this point he laid stress in his great work, the Ymago Mundi, and an edition of it having been published in the days when Columbus was thinking most closely upon the problem of a westward voyage, it naturally exercised much influence upon his reasonings. Among the treasures of the library at Seville, there is nothing more interesting than a copy of this work annotated by Columbus himself; from this very copy it was that Columbus obtained confirmation of his belief that the passage across the ocean to Marco Polo's land of Zipango in Asia was short. But for this error, based upon a text supposed to be inspired, it is unlikely that Columbus would have had the courage to undertake his voyage. It is a curious fact that this single theological error thus promoted a series of voyages which completely destroyed not only this but every other conception of geography based upon the sacred writings.*

5. THE CHARACTER OF THE EARTH'S SURFACE.—It would be hardly just to dismiss the struggle for geographical truth without referring to one passage more in the history of the Protestant Church, for it shows clearly the difficulties in the way of the simplest statement of geographical truth which conflicted with the words of the sacred books.

In the year 1553 Michael Servetus was on trial for his life at Geneva on the charge of Arianism. Servetus had rendered many services to scientific truth, and one of these was an edition of Ptolemy's Geography, in which Judea was spoken of, not as "a land flowing with milk and honey," but, in strict accordance with the truth, as, in the main, meager, barren, and inhospitable. In his trial this simple statement of geographical truth was used against him by his arch-enemy John Calvin with fearful power. In vain did Servetus state the fact that he had simply drawn the words from a previous edition of Ptolemy; in vain did he declare that this statement was a simple geographical truth of which there were ample proofs; it was answered that such language "necessarily inculpated Moses, and so grievously outraged the Holy Ghost." †

In summing up the action of the Church upon Geography, we must say, then, that the dogmas developed in the strict adherence to Scripture and the conceptions held in the Church during many centuries "always, everywhere, and by all," were, on the whole, steadily hostile to truth; but it is only just to make a distinction here between the religious and the theological spirit. To the religious spirit are largely due several of the noblest among the great voyages of discovery. A deep longing to extend the realms of Christianity influenced the minds of Prince John, of Portugal, in his great series of efforts along the African coast; of

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* For this error, so fruitful in discovery, see D'Ailly, Ymago Mundi (my own copy is of 1490); the passage referred to is folio 12 verso. For the passage from Esdras, see chap. vi, verses 42, 47, 50, and 52; see also Zöckler, Geschichte der Beziehungen zwischen Theologie und Naturwissenschaft, vol. i, p. 461. For one of the best recent statements, see Ruge, Gesch. des Zeitalters der Entdeckungen, Berlin, 1882, pp. 221 *et seq.* For the letter of Columbus acknowledging his indebtedness to this mistake in Esdras, see Navarrete, Viajes y Descubrimientos, Madrid, 1825, tome i, pp. 242–264; also Humboldt, Hist. de la Géographie du Nouveau Continent, vol. i, pp. 68, 69.

† For Servetus's geographical offense, see Willis, Servetus and Calvin, London, 1877, p. 325. The passage condemned is in the Ptolemy of 1535, folio 41. It was discreetly retrenched in a reprint of the same edition. As to the mixture in the motives of Columbus, it may be well to compare with the earlier biographies the recent ones by Dr. Winsor and President Adams.

Vasco da Gama, in his circumnavigation of the Cape of Good Hope; of Magellan, in his voyage around the world, and doubtless found a place among the more worldly motives of Columbus.

Thus, in this field also, from the supremacy accorded to theology, we find resulting that tendency to dogmatism which has shown itself in all ages the deadly foe not only of scientific inquiry but of the higher religious spirit itself, while from the love of truth for truth's sake, which has been the inspiration of all fruitful work in science, nothing but advantage has ever resulted to true religion.

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